



ACHIEVING SCIENCE LEARNING OUTCOMES AT SECONDARY STAGE LEVERAGING INFORMATION AND COMMUNICATION TECHNOLOGY

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ABSTRACT

Research and development activities in the education environment are always the prime focus of the teaching-Learning process for their sustainable Outcomes for humankind. In the past two decades, science and technology are emerging subject areas. As per the need of the times, and knowledge-seeking behavior through different modes and mediums of Information Communication and Technology, have effectively occupied place in teaching -learning. Focusing on issues and challenges related to Teaching-learning processes and outcomes, National Council of Educational Research and Training (NCERT) developed Learning Outcomes document for Secondary School level in Nine Subject areas. Science is also one of the subjects for both Classes IX and X at Secondary Stage. Access and use of ICT can give effective inputs to reduce the gap of the traditional method of teaching-learning of Science education and contribute to the attainment of Learning Outcomes. The effective use of ICT in terms of Learning Outcomes in Science is needed to make learning simpler and application oriented. This paper discusses the Learning Outcomes and its important features, leveraging ICT for achieving Learning Outcomes in Science at Secondary Stage and applying Assistive technology to perform Physics, Biology and Chemistry activities and experiments. Further, to attain Learning outcomes through ICT, important steps have been discussed. The suggestions are put forth for the attainment of Learning-Outcomes.

KEYWORDS: ICT, Learning Outcomes, Assistive technology, Augmented Reality, Pedagogical Processes.

INTRODUCTION:

Effectively achieving Learning Outcomes of the teaching-learning processes in theory and practical is the need of the hour. Various attempts have been made and policies were formulated improve and uplift status of education. D.S Kothari Commission (1962-64) to focused on Science education and developing scientific attitude. Further, National Policy of Education 1986, Programme of Action 1992 emphasized on the minimum levels of learning to ensure that "all children acquire at least the minimum levels of learning. Overall development of Learners was emphasized in the National Curriculum Framework 2005. Information and Communication has now emerged as a major player in education.

ICT in School and e-learning Teacher education needs to orient and sensitize the teacher to distinguish between critically useful, developmentally appropriate and the detrimental use of ICT. In a way, ICT can be imaginatively drawn upon for professional development and academic support of the pre-service and in-service teachers. (NCFTE-2009)

Right of Children to free and compulsory education Act, 2009 created a positive effect on school education. A sound National Policy on Information Communication and Technology was framed in the year 2012, for the comprehensive use of ICT and holistic development of School education. ICT has now become an essential and inseparable part of the education environment and its usage has gradually increased in Indian Schools through different government flagship programmes like Sarv Siksha Abhiyan (SSA), RMSA etc.

Information Communication and Technology (ICT):

The term information and communication technology in educational scenario is very broad, the technology is used in different purposes to convey the information through different mode/medium to stakeholders. ICT is widely used to transmit, store, create, convert, display, or exchange of the information through various technological devices. It may be widely perceived as the devices, tools, content, resources, forums, and services (digital and those that can be converted into or delivered through digital forms), to accomplish and realize the goals of information transaction during the teaching-learning. It may be further used for and enhancing the ways for assessing and augmenting resources for capacity building and management of educational system. The new ways of ICT usage are interactive digital content, internet and other satellite communication devices, radio and television services, web-based content repositories, interactive forums, learning management systems, and management information systems. In the information age, digitization of information, evaluation of content, deployment, management of content for capacity development of knowledge ICT is used for qualitative teaching-learning process and in turn to attain the learning outcomes.

Learning Outcomes (Los):

All around quality improvement of learners require a multi-prolonged approach for quality education and its effective transaction. Therefore, teachers have to work as facilitator and mentor to focus on students holistically. From ancient times to the present digital age various pedagogical methods are used by teachers.

Students look forward to schools for learning. However, report (Global Monitoring Report-2015); achievement surveys (Annual Status of Education Report (ASER), National Achievement Survey (NAS), reported a decline in outcomes of reading, mathematical and numerical abilities of children. Learning Outcomes can be reflected in terms of achievement by learner during the course of study. *Rabindranath Tagore stated that "the highest education is that which does not merely give us information but makes our life in harmony with all existence".* Bloom's Taxonomy of Education Objective (2001) for learners expressed six levels from the lowest to the highest and expected learning outcomes as expressed in the table below.

Table 1: Bloom's Taxonomy of Education, Learning Outcomes and ICT

S.No	Instructional Objectives	Learning Outcomes include	ICT can Leverage
1.	Knowledge	Define, List, Recognize	Simpler, accuracy, accessible, locate and regenerate
2.	Understanding	Characterize, describe, explain, identify, locate, recognize, sort	Visually, multilingual, create database interactive
3.	Applying	Choose, demonstrate implement, perform	One-to-many, many-to-one Digitally presentation, online and offline, mass group or individual, itself or through help of teacher, instructor etc.
4.	Analyzing	Analyse, categorize, compare, differentiate,	Analysis through using online and offline ICT resources.
5.	Evaluating	Assess, critique, evaluate, rank, rate	Help to reduce the time frame, accuracy in the evaluation
6.	Creating	Construct, design, formulate, organize, synthesize	Construct more elaborative, design content relevant to learners stage, organize complex to visual form, and synthesize into attractive manner

Source: Derived from Bloom's Taxonomy

Learning Outcomes at Secondary Stage:

Teacher use a variety of pedagogical processes, tools and techniques in teaching-learning process. Challenges often arise when the classroom treatment is run of the mill stuff. Many pertinent questions arise, Why teacher teach?..Why are learning outcomes not achieved by the students? ...What will be the implications of inadequate achievement of students ...will improved teaching-learning processes lead to change in the in their attitude, perception, competencies, observations?...Will they be able to accomplish the task at various levels in future life. With this perspective, the National Council of Educational Research and Training, in 2017, developed the Learning Outcomes for the elementary stage addressing the concerns of Right of Children to Free and Compulsory Education (RTE) Act, 2009 on the learning levels of children. NCERT also conducted discussions with various stakeholders, as well as the capacity building of teachers. As a follow up of this, the States / UTs had taken an initiative to disseminate learning outcomes in their schools. It is in this context, that the demand for learning outcomes for the secondary stage from the different school education boards, SCERTs, etc. increased. Addressing this demand, the NCERT has developed the Learning Out-

comes for the Secondary Stage in all subject areas in school education, in the year 2019, Learning outcomes document was developed in various consultations with stakeholders from all over the country. These LOs are developed in nine subjects viz., Hindi, English Language, Mathematics, Science, Social Science, Urdu, Sanskrit, Health & Physical Education and Art Education. The document is both in Hindi and English version. Education. In the document, pedagogical processes match the learning needs of students. Adequate space has been given to national and social concerns such as gender, inclusion, constitutional values, protection of environment, and children with special needs in the classroom environment. Moreover, the 21st century skills of problem solving, critical thinking, creativity, etc., are also an integral part. Besides, these learning outcomes have strong linkages with Sustainable Development Goals-4 with regards to the concern of universal quality education.

Learning Outcomes in Science:

Science is a dynamic, expanding body of knowledge, covering newer domains of experience everyday. It is a important for a science teacher to know the outcomes of his/her endeavors in the classroom. The Learning Outcomes at the Secondary stage focus on the various scientific and pedagogical content knowledge through interconnected processes of principles, theories, experiments, observations, formulating hypotheses, and assessment. According to the NCF-2005, Science is treated as one of the core subjects in the secondary schools. All possibilities beyond the expectation of just completing the syllabus given in the textbooks of Science at IX and X standard should be considered for developing scientific temperament. This document takes into consideration the experiences, process skills, critical thinking, problem solving as well connections across the disciplinary boundaries. A wide range of strategies and activities are suggested for enriching teaching learning processes to meet curricular expectations at secondary stage.

Apart from developing a scientific temper, the document suggests various pedagogical processes for achieving the listed expected learning outcomes.

Table 2: Learning Outcomes of Science at Secondary Stage (Class IX)
A snapshot

Suggested Pedagogical processes	Learning Outcomes
The learners may be provided with opportunities individually or in groups and encouraged to	The Learner will be able to attain the following Learning Outcomes
<ul style="list-style-type: none"> observe, group or classify materials design and carry out activities study the daily life experiences conduct survey to understand the process of spreading of diseases gather data for calculating different physical quantities. collect and analyse wide variety of graphs from newspapers, magazines or the internet write chemical formulae of simple compounds, chemical equations, etc select and use appropriate devices for measuring physical quantities. collect information from books, e-books, magazines, internet, etc observe various technological devices and innovative exhibits share and discuss their beliefs and views 	<ul style="list-style-type: none"> differentiates materials, objects, organisms, phenomena, and processes, based on properties or characteristics classifies materials, objects, organisms, phenomena, and processes, based on properties or characteristic plans and conducts investigations or experiments to arrive at and verify the facts, principles, phenomena or to seek answers to queries on their own relates processes and phenomena with causes and effect explains processes and phenomena calculates using the data given draws labelled diagrams, flow charts, concept maps, graphs analyses and interprets graphs and figures uses scientific conventions, symbols, and equations to represent various quantities, elements, and unit measures physical quantities using appropriate apparatus, instruments, and devices applies learning to hypothetical situation applies scientific concepts in daily life and solving problems derives formulae, equations, and laws draws conclusion, describes scientific discoveries and inventions designs models using eco-friendly resources exhibits values of honesty, objectivity, rational thinking, freedom from myths, superstitious beliefs while taking decisions, respect for life, etc communicates the findings and conclusions effectively applies the interdependency and interrelationship in the biotic and abiotic factors of environment to promote conservation of environment

Source: Learning Outcomes at Secondary Stage-2019 (NCERT)

Table 3: Learning Outcomes of Science at Secondary Stage (Class X)
A snapshot

Suggested Pedagogical processes	Learning Outcomes
The learners may be provided with opportunities individually or in groups and encouraged to	The Learner will be able to attain the following Learning Outcomes
<ul style="list-style-type: none"> recognise the difference between reactions observe to understand the difference in the temperatures investigate the ways of segregation of waste material explore the relationship between two physical quantities find out 'why' and 'how' of processes or phenomena observe diagrams collect wide variety of graphs from newspapers, magazines, or the internet study how chemical equations are balanced using simple mathematical skills get familiar with New Cartesian Sign Convention perform a role-play on ecosystem in a hypothetical situation derive equations, formulae, laws, etc study the features inherited through genes, collect print and non-print materials by exploring the library and the internet about scientists and their findings encourage learners to visit science museums, biodiversity parks, aviaries, zoological parks, botanical gardens, fisheries, poultry farms, factories, etc collect eco-friendly, commonly available materials visit classrooms, laboratories, library, toilets, playground, etc share their findings of the activities, projects, and experiments 	<ul style="list-style-type: none"> differentiates materials, objects, organisms, phenomena, and processes, based on, properties and characteristics classifies materials, objects, organisms, phenomena, and processes, based on properties and characteristics plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on their own relates processes and phenomena with causes and effects explains processes and phenomena draws labelled diagrams, flow charts, concept maps, and graphs analyses and interprets data, graphs, and figures calculates using the data given uses scientific conventions to represent units of various quantities, symbols, formulae, and equations handles tools and laboratory apparatus properly; measures physical quantities using appropriate apparatus, instruments, and devices applies learning to hypothetical situations applies scientific concepts in daily life and solving problems derives formulae, equations, and laws draws conclusion takes initiative to know about scientific discoveries and inventions exhibits creativity in designing models using eco-friendly resources exhibits values of honesty, objectivity, rational thinking, and freedom from myth and superstitious beliefs while taking decisions, respect for life, etc communicates the findings and conclusions effectively makes efforts to conserve environment realising the inter-dependency and inter-relationship in the biotic and abiotic factors of environment

Source: Learning Outcomes at Secondary Stage-2019 (NCERT)

In table 2 and 3, few pedagogical processes and expected Learning Outcomes are mentioned for secondary level (Class IX and X) students. Some of pedagogical processes suggest the use of internet and ICT tools to collect information about the different items, and related study material for teacher and students. To share wide information in stipulated time and address the challenge of how availability of resources ICT proves to be a great boon for both students and teacher alike. Different stakeholders can use ICT to address various issues in teaching and learning.

ICT to achieve Learning Outcomes:

ICT plays an important role in the teaching-learning processes, it enables the techniques, tools, content, and resources that improve the quality and efficiency of the classroom interactive. It helps to project the information through visual and interactive manner, create self-learning modules; online-based learning through simulations, providing hands-on practice without any geographical boundaries and time barriers. Digitally developed materials help to stimulate the thought process in a teaching-learning. Benjamin, E.W (2007) studied the Development of interactive multimedia cd based learning courseware for learning physics at the higher secondary level and findings of the study reveal that the dominance of the interactive multimedia CD-based learning courseware was established over the conventional method of instruction. Further, the experimental group had expressed a more favorable attitude towards the interactive multimedia CD-based learning courseware.

The various facts, processes can be shown live in the videos, interactive programmes, and programmes developed on augmented reality. Application of these strategies by using ICT enabled tools online/offline will contribute to enrich the classroom practice. The wide variety of ICT based teaching learning material works as catalyst for strengthening the relations of teachers and students Adonis,(2006) described the use of technologies as the sure way to achieve efficiency in the educational objective of the secondary education through digital libraries, e-mail, internet and other forms of e-learning resources. Teachers of different streams can co-operate and participate in the selection, development and critical evaluation of the information of digital content and resources. ICT provides various tools to write the script with examples that help to design and create new programmes for teaching-learning. It also helps to use variety of study material in the classroom. ICT helps in the time management in the classroom and assessment of students as well as facilitates wider reach to disseminate the content to masses.. Satellite-based facilities like EDUSAT terminals, Direct to Home Base service (DTH) and the other digital media DVDs, BRDs and web-based facilities help to develop the new programmes in the regional languages too.

Augmented Reality to achieve Learning Outcomes:

Flexibility in the pedagogical processes should lead to providing varied learning experiences to the students. Hence, the pedagogy should be based on psycho-

logical development, emphasise on the ways and process of science like observation, questioning, designing investigation, hypothesising, analysing and interacting explanations with evidences, justifying explanations, thinking critically value clarification etc. Thus, science learning requires a new techniques that enable students to understand dynamic science concepts. Conventional teaching learning process and methods need to be updated and supported technologically. Technology simplifies the process of learning with psychological features and enhances the productivity. Therefore, the assistance of ICTs science subject is widely welcome, when taken up by teachers, students and parents alike. Moreover, technology is required and extremely helpful in explaining concepts of science, (Physics, Chemistry, Botany and various other interrelated scientific concepts) to understand in depth the complex scientific terms and processes. ICT integrated learning technique motivates, enhances collaboration, provides various opportunities to construct their own ideas and stimulates innovative thinking. Additionally, the interactive multimedia learning applications offer to enrich the learning process and enhance the capacity to represent information in a systematic way. Augmented Reality (AR) with the addition of multimedia elements and theoretical base help to reinforce motivation. It also facilitates a learning experience beyond belief and expectation. It combines virtual information with the real environment in the real-time and enhances the user's perception such as vision, hearing, and touch along real educational material. Due to the increasing use of mobile devices, Augmented Reality application software is easily accessible to the teachers.

Teacher as ICT enabler :

A teacher is a medium to bridge the gap areas and fulfill all the possible requirement of Information and knowledge to its students. Teachers role in the digital environment is to be updated with new ICT developments. A digitally literate teacher helps to learn digital skills provides a creative way to the students. Individual differences can also be called through use of ICT.

The overview of the teaching-learning process through ICT and attainment of Learning Outcomes by students shows in the Figure 1. For example, demonstrating Laboratories experiment, activities can be done through Online Laboratories.

It is the convenient for both teacher and students in the absence of functional laboratories.

There are various situations in which some of them are listed below other different approaches where ICTs can play a crucial role to support teaching-learning of science and in turn achieving the expected Learning Outcomes.

• Central role in the Learning Process

Teachers work as facilitator to manage the classroom and facilitate students in terms of what, when and why to learn ,appropriately at various stages of understanding concepts through ICT, eg. Teachers can plan a lesson using online and offline ICT tools well in advance. This can be reformulated with help of ICT resources. When teachers teach in classroom using ICT, the visual effects captured more attention among learners and help in understanding concept clearly.

• **Language barrier and regional effect in the conversation can be overcome** through multimedia and interactive programmes. This would facilitate students coming from diverse language backgrounds.

• Cognitive Effort

Stakeholders can see images in 3 dimensions; see the unseen and juxtapose information related to their textbooks. Science usually needs a high degree of abstraction, ICTs may help to scale the element of images and activities in many affordable ways.

Artificial Intelligence can help:

To move a step further for personalized education, lengthening the attention span of students, help differently abled students to differentiate various shapes (2D and 3D) and detection of Text, alarm for direction etc., help the teachers to document and maintain records and ,help in continuous assessment .

ICT tools for achieving Learning Outcomes in Science education

Some suggested ICT tools (Websites, Links, software)can be used for achieving learning outcomes during teaching-learning processes.

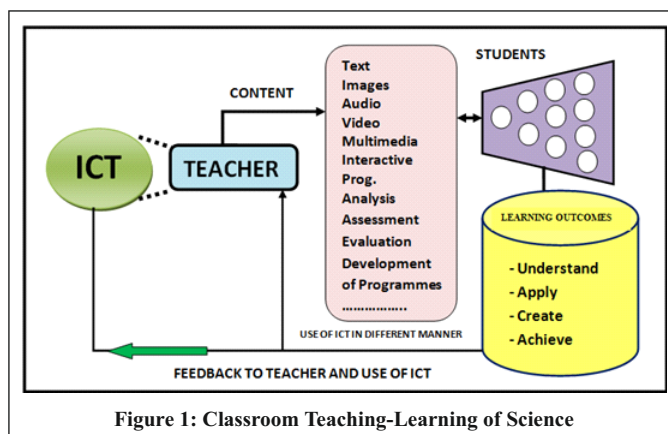


Figure 1: Classroom Teaching-Learning of Science

Table 3. ICT tools for Learning Science

ICTs tools for Science	Specifications				Objective(s)
	Website/link	Online	Offline	Operating System	
Avogadro	https://avogadro.cc/	-	√	Mac, Linux and Windows	Advanced molecule editor and visualizer designed for cross-platform use in computational chemistry, molecular modeling, bioinformatics, materials science, and related areas.
Olabs	https://www.olabs.edu.in/	√	√	Windows and Android phone	For (physics, biology chemistry) experiments, activities, animation, videos, interactive simulation and viva-voice etc. it provides hands-on training programme
Epathshala AR app	Google play store	√	-	Android 4.1 and up	Augmented reality (physics, biology & chemistry) for experiments and activities interactively.
Phet Interactive Simulation	https://phet.colorado.edu/	√	√	Windows 7 and Android phone	Simulation, Teaching, research and accessibility for Physics, Chemistry, Biology, Math, Earth Science for interactive learning
Microsoft Excel	https://www.microsoft.com/en-in/microsoft-365/excel	√	√	Mac, Windows and Android phone	Data record & analysis, calculation, graphing tools, pivot table
NROER	https://nroer.gov.in/welcome	√	-	Windows and Android phone	Open educational resource viz., Science (Physics, Chemistry , Biology), in document, video, audio and interactive programme
Khan academy	https://www.khanacademy.org/	√	-	Windows and Android phone	Video programme for Science (Physics, Chemistry , Biology)

Kishore Manch	google play store	√	√	Windows, Android phone, Tele-vision	Live interaction between students and subject experts through the telecast of educational contents on SWAYAMPRAKASH through an online platform from their home. Covering area Science including other subjects and Live Counselling for students
ACD/CHEM SKETCH	https://www.acdlabs.com/resources/freeware/chemsketch/	-	√	Windows 64 bit	Draw chemical structures including organics, organometallics, polymers, and Markush structures, calculation of molecular properties in 2D and 3D structure cleaning and viewing, functionality for naming structures.
Virtual Lab Simulation	http://chemcollective.org/home	√		Windows and more	Online Resources for Teaching and Learning Chemistry
NCERT BOOKS	http://ncert.nic.in/ebooks.html	√	√	Windows and android phone	Textbooks, flipbook, ePub and etextbooks of states and UTs
Swayam	https://swayam.gov.in/	√	-	Windows and Android phone	Online Course for Physics, Biology and Chemistry, other education related course available
H5p	https://h5p.org/	√	-	Windows 32 bit and more	Interactive videos, interactive presentations, quizzes, interactive timelines and more have been developed and shared using H5P

CONCLUSION:

Learning Outcomes at secondary stage is one of the informative document to understand the science education in depth to a great extent. Delivering the actual meaning and wisdom of science at the grass-root level through this document is not sufficient due to lack of skilled workforce, tools and techniques, trained teachers, adequate resources and missing of current trend of pedagogical processes. These are essential prerequisites of learning science that are unavailable at certain levels in urban, rural and remote areas. As a result, interest in science education is declining in the present times. This document will help to achieve the Learning Outcomes among various stakeholders by integrating and leveraging of ICT through online and offline mode, and plug in the major gap areas. Therefore, it is necessary to provide the orientation programmes and organize hands-on practice in a different phases of the academic session leveraging ICT for achieving Learning Outcomes in Science.

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